Conservation of Momentum in Two Dimensions

Note the slight difference in the conservation of momentum statement:

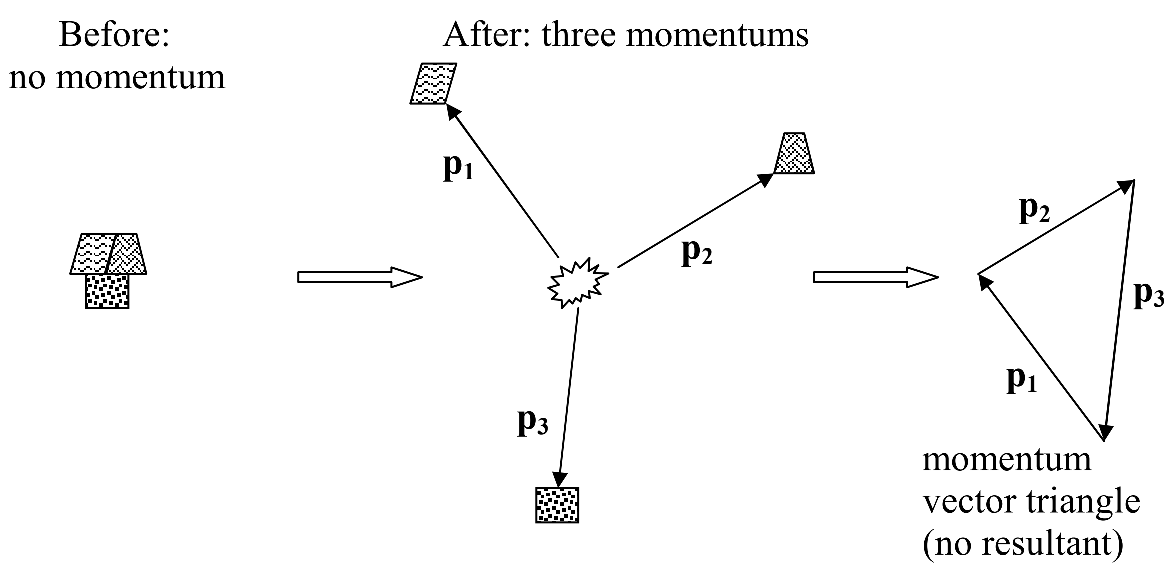
total vector momentum before = total vector momentum after

In other words, vector addition of momentum quantities is needed to solve for unknown values.

Explosions

Before exploding, a stationary object has zero momentum. Therefore, the vector sum of the momentums of all particles after the explosion must also equal zero. There is no resultant momentum vector.

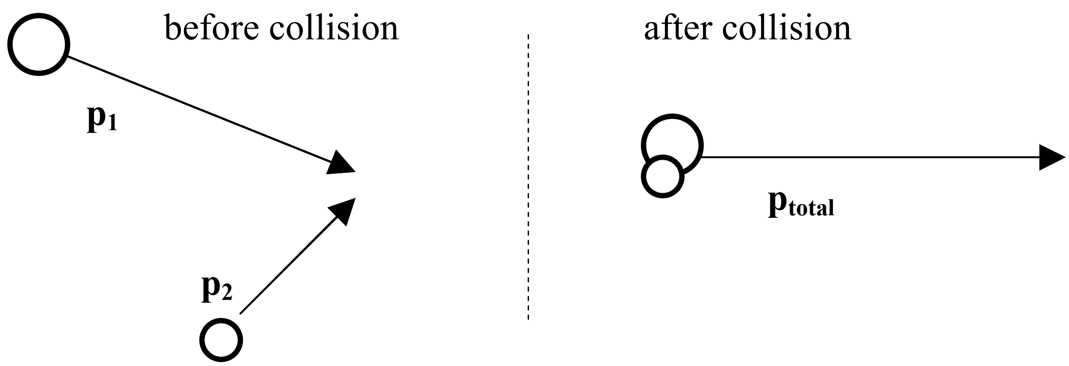
If there are three masses in the explosion, adding the momentums will form a *closed* triangle of momentum vectors.



Example #14: An object, at rest, explodes into three pieces, each travelling parallel to the ground. The first piece has a mass of 3.0 kg and travels at 4.0 m/s (30º N of E). The second piece has a mass of 4.0 kg and travels 3.0 m/s (30º S of E). Find the speed and direction of the third piece if its mass is 5.0 kg.

(see Momentum Ex 14 for answer)

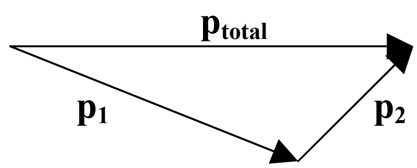
<u>Oblique Collision, two particles sticking together</u>.
When two masses collide and stick together, a third momentum vector is formed. From conservation of momentum, the sum of the two vectors before the collision must equal the single resultant momentum vector after the collision.



total vector momentum before = total vector momentum after

$$\mathbf{p_1} + \mathbf{p_2} \quad = \quad \mathbf{p_{total}}$$

This forms a momentum vector triangle:

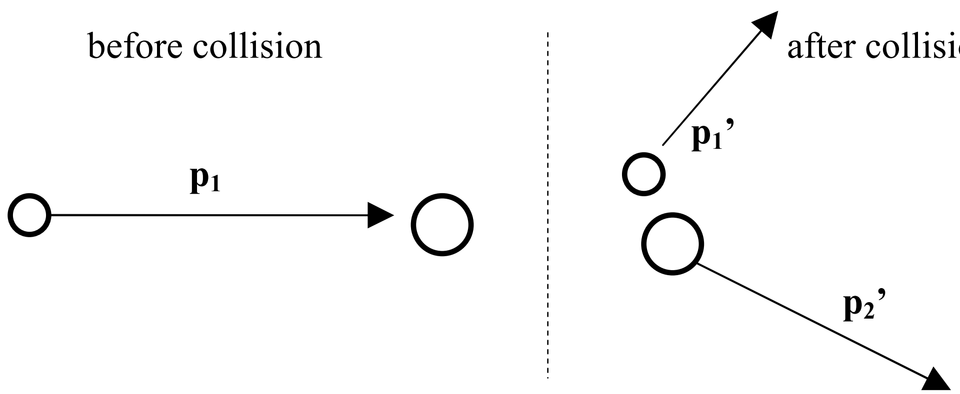


Use sine and/or cosine laws to solve for required values.

Example #15: A 100 kg football player going 3.0 m/s north, tackles another player of mass 150 kg going 1.5 m/s east. The players entangle. What is their combined speed and direction?

(see Momentum Ex 15 for answer)

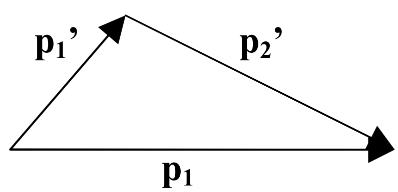
<u>Oblique collision, moving mass strikes a stationary mass.</u>
From conservation of momentum, the single vector momentum of the projectile mass before must equal the <u>sum</u> of the vector momentums of the projectile mass and target mass after. This forms another momentum triangle, though the set-up is slightly different from the previous example.



total <u>vector</u> momentum before = total <u>vector</u> momentum after

$$\mathbf{p_1} \quad = \quad \mathbf{p_1' + p_2'}$$

Adding the two "after" vectors equals the first projectile vector:



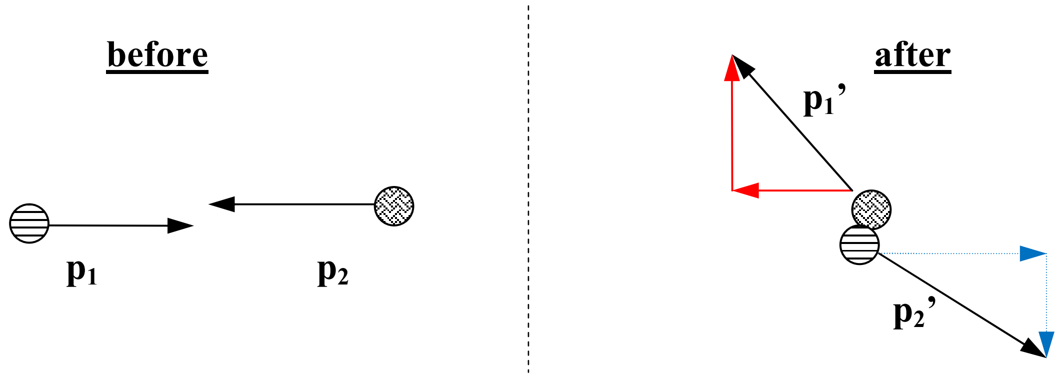
Again, use sine and/or cosine laws to solve for required values.

Example #16: A 2.0 kg ball going 5.0 m/s strikes a stationary 4.0 kg ball. After the collision, the second ball goes off at 1.11 m/s at 54° from the direction of the original ball. What is the speed and direction of the first ball?

(see Momentum Ex 16 for answer)

Note: If *<u>more</u>* than three vectors are involved in a conservation of momentum problem, parallel and perpendicular components are used to solve for the required quantities.

Consider two balls that collide obliquely:



Draw components in this diagram.

- Start with: **total momentum before = total momentum after**
- Solve for both $\mathbf{p_x}$ components and $\mathbf{p_y}$ components:

X-components	**Y-components**
before = after	**before = after**

- Then use the net components to find the resultant momentum.